



Figure 3.19. Annual Drinking Water Dose from Technetium-99 in Groundwater Southeast of the 200 East Area from All Hanford Sources Including ILAW

3.5 Areas of Uncertainty, Incomplete, or Unavailable Information

This section discusses uncertainties associated with alternatives evaluated in the HSW EIS, and takes into account areas where information is either incomplete or unavailable. Because an EIS is by nature a document prepared during the planning stages for a proposed action, information needed to evaluate environmental impacts of the activities in detail may not always be available. In some cases, there are uncertainties that cannot be resolved by collection or development of additional information, such as the uncertainties associated with projected environmental impacts at very long times in the future, or those associated with inherent variability in human and ecological systems. The approach used to account for these uncertainties would vary with the nature of the impact being evaluated and the methods used for the assessment. The individual analyses of environmental impact areas in Section 5 provide additional detail regarding uncertainties unique to each evaluation. Major areas of uncertainty associated with the proposed waste management alternatives evaluated in this HSW EIS are described in the following sections.

3.5.1 Waste Volumes

The volume of wastes that could ultimately be managed at Hanford represents one of the larger uncertainties associated with the analyses in this EIS. Many of the impact assessments depend on the waste volume that ultimately requires treatment or disposal onsite. Forecasts of future waste volumes from Hanford generators have been compiled for a number of years, and have been shown to be reasonably accurate, if somewhat conservative overall (See Appendix B). Potential waste receipts from

1 offsite generators are associated with uncertainties due to cost, schedule, and other factors. The
2 performance assessment process may also limit incoming waste quantities in order to ensure compliance
3 with applicable requirements. The HSW EIS accounts for this uncertainty by evaluating a range of waste
4 volumes as described in Section 3.3. Those waste volumes represent estimates of the minimum and
5 maximum waste quantities reasonably expected to be received at Hanford during active waste manage-
6 ment operations. The basis for the waste volumes is described in Appendix B.

8 **3.5.2 Waste Inventories of Radioactive and Hazardous Materials**

9
10 The quantities of radioactive and hazardous components in waste also contribute to environmental
11 impacts, particularly those associated with air emissions and long-term performance of disposal facilities.
12 The basis for waste inventories varies with the type of waste and its source, and may include information
13 such as process knowledge or direct assay. In general, inventories for wastes received in recent years are
14 expected to be associated with less uncertainty than those disposed of in the early 1970s. Wastes received
15 in later years are more fully characterized because of improved analytical capabilities and added require-
16 ments for record keeping. Inventories of hazardous chemicals in mixed waste were not required to be
17 determined or documented before the application of RCRA to mixed radioactive waste to DOE in 1987.
18 Therefore uncertainty regarding the content of hazardous materials in wastes disposed of before that time
19 is generally higher than for radionuclides. The HSW EIS analyses generally account for those uncer-
20 tainties by making conservative assumptions regarding waste inventories based on process knowledge,
21 assays of previously received waste, or other available information. For example, the inventory of
22 iodine-129 in past and potential future waste receipts has been estimated using the total production at
23 Hanford, sampling of releases to the atmosphere from fuel processing facilities, and analytical informa-
24 tion on tank waste and other waste streams as described in Appendix L.

25
26 Chemical inventories in pre-1988 waste have not been specifically estimated for analysis in the HSW
27 EIS because data are generally lacking in the absence of sampling and characterization of hazardous
28 chemicals in the previously disposed waste. However, post-1988 solid waste has been characterized and
29 typically contains only small quantities of hazardous materials (see Appendix F). Most hazardous mate-
30 rials used in large quantities at Hanford were organic liquids or solutions containing inorganic compounds
31 and metals such as cadmium. Some of those contaminants have been detected in groundwater as a result
32 of past liquid waste disposal practices. Other regulated hazardous materials, such as lead, were typically
33 in a solid non-dispersible form and are not highly mobile in groundwater. Sampling of groundwater and
34 soil in the vicinity of solid waste disposal facilities has not provided evidence that these facilities
35 contributed to existing groundwater contamination (Hartman et al. 2002). A previous evaluation of waste
36 disposal sites confirmed that groundwater contamination by hazardous chemicals was primarily a result of
37 past liquid discharges rather than solid waste disposals (DOE 1996).

38
39 Disposal of untreated liquids to ground was discontinued in 1995, and there is an ongoing program to
40 characterize and remediate soil and groundwater contaminated by past discharges (Hartman et al. 2002).
41 For example, some LLBGs in the 200 West Area were sampled recently as part of an ongoing CERCLA
42 investigation to characterize and remediate past carbon tetrachloride discharges in the vicinity of the
43 Plutonium Finishing Plant. Sampling detected the presence of carbon tetrachloride vapor in soil at the
44 bottom of some disposal trenches about 4.6–6.1 m (15–20 ft) below ground. The source of the vapor

1 could not be determined from the initial sampling, but was estimated to be either waste in the disposal
2 trench, or lateral migration of vapor from former liquid discharge sites in the vicinity. The sampling
3 risers were capped except during sample collection, and measured vapor concentrations in air at the
4 ground surface were well within workplace exposure standards. Because of those results, and because the
5 vapor is approximately five times the density of air, there was no evidence that potentially hazardous
6 releases to the atmosphere had occurred. However, additional soil sampling has been planned to investi-
7 gate the source of the vapor and to determine whether there may have been liquid carbon tetrachloride
8 releases to soil beneath the trenches. Depending on those future findings, remedial actions would be
9 carried out during retrieval of stored transuranic waste from the trenches or at closure of the LLBGs.

10
11 MLLW currently in storage, and MLLW that may be received in the future, would be treated to
12 applicable standards for land disposal, and is not expected to present a hazard over the long term because
13 the hazardous components would either be destroyed or stabilized by the treatment. Inventories of
14 hazardous materials in stored and forecast waste are either very small, or consist of metals with low
15 mobility (see Appendix F). Disposal facilities containing pre-1988 waste would be evaluated using
16 RCRA past practice or CERCLA processes to determine whether remedial action would be required
17 before the facilities are closed. Therefore the long-term risks from these wastes would either be
18 determined to be minimal, or the waste would be remediated by removal or treatment to reduce its
19 potential hazard.

20
21 Hanford's high-level waste tanks also contain a complex mixture of radionuclides and chemicals,
22 which adds a degree of uncertainty to the analyses associated with ILAW disposal. Historical data, such
23 as chemical purchase invoices, records of waste transfers, and process knowledge, have been used to
24 estimate total inventories of materials in the tank waste collectively. There is an ongoing waste charac-
25 terization program to better determine the contents of each individual tank through sampling and analysis
26 to support safety evaluations and remedial action decisions. Collection of that information continues, but
27 is not yet complete. The lack of detailed characterization information on a tank-by-tank basis adds a level
28 of uncertainty to certain aspects of the tank waste treatment project. However, that information is less
29 critical to determining the long-term impacts of disposal, which are based on the total ILAW inventory.
30 Treatment processes that would affect the composition and form of the final product are still under
31 investigation as well. Some of the processes under consideration have not been applied to this type of
32 waste, or have not been used on the scale necessary for the project, and some uncertainty will remain in
33 these areas until the processes are more fully developed and tested. To account for these uncertainties,
34 the assumptions in this EIS are based on waste characterization and processing data that are intended to
35 provide a conservative, or bounding, analysis of impacts for the alternatives under consideration.

36 37 **3.5.3 Fate and Transport of Radioactive and Hazardous Materials**

38
39 Estimating transport of hazardous materials or radionuclides through various environmental pathways
40 to human or ecological receptors is a complex process, often requiring extensive input data. In order to
41 predict the potential for future impacts, it is typically necessary to use computer models to simulate their
42 transport and receptor exposure rates. Computer modeling may also be used to estimate the impacts from
43 past releases where the quantity of released material is too small to measure in the field, or where contam-
44 inants arrive at the receptor location at very long times after the release occurs. The amount of data

1 required for a particular simulation depends on the transport medium and exposure pathways of interest.
2 The information needed to model transport through the environment may be relatively straightforward,
3 such as measurements of wind direction and velocity, or highly complex, such as groundwater flow rates
4 and directions. Likewise, exposure of receptors can depend on the behaviors of individuals or popula-
5 tions, such as food consumption rates.
6

7 With respect to long-term performance of disposal facilities, the transport of contaminants depends on
8 performance of the waste form, factors affecting infiltration of water through the waste, and flow rates of
9 groundwater, all of which are subject to substantial uncertainty over the long term. Contaminant release
10 rates depend on treatment processes and the resulting physical and chemical characteristics of the waste
11 form. For example, future decisions regarding the tank waste treatment process may affect the compo-
12 sition and long-term performance of the ILAW product, and some uncertainty will remain in these areas
13 until the processes are more fully developed and tested. Performance of different ILAW waste forms is
14 discussed briefly in Appendix G. Performance of the engineered disposal system, such as the use of
15 greater confinement (HICs or trench grouting), trench liners, or infiltration barriers over the disposal
16 facility is also difficult to predict over the very long time periods used for the analyses in performance
17 assessments and in this EIS. Other factors such as the geochemical environment, climate, and natural
18 recharge rates in the future add to the uncertainty in predicting contaminant transport. In general, inter-
19 actions among waste components that could change the geochemistry in the immediate vicinity of the
20 disposal facility, such as the possible presence of organic chemicals in some previously disposed waste,
21 are not expected to affect contaminant mobility over the long term. Such interactions would require
22 relatively high concentrations of contaminants or large volumes of liquids to substantially influence
23 contaminant mobility over the entire transport path. The solid wastes considered in this EIS do not
24 typically contain large enough quantities of liquid organic chemicals or other potentially mobilizing
25 agents to affect transport by this mechanism (See Appendix G).
26

27 After contaminants reach the accessible environment, potential impacts are controlled by the mech-
28 anisms that result in exposure to individuals or populations. Recent studies of long-term transport of
29 contaminants in groundwater indicated that, for estimates of human health effects, variability with regard
30 to individual behavior and exposure affects uncertainty in the result more than variability in inventory,
31 release, or environmental transport of the contaminant (Bryce et al. 2002).
32

33 To account for these uncertainties, the assumptions in this EIS are based on waste characterization
34 and processing data that are intended to provide a conservative, or bounding, analysis of impacts for the
35 alternatives under consideration. Engineered systems are assumed to be effective for a reasonable but
36 limited time compared to the period of analysis. Uncertainties associated with exposure parameters are
37 typically addressed by using conservative assumptions in the model simulations, that is, assumptions that
38 tend to maximize the exposure of individuals or populations to contaminants. An example is the use of
39 unfavorable atmospheric dispersion conditions to maximize the downwind concentrations of hazardous
40 materials in accident simulations, as in the analyses reported in Section 5.11. In other cases, each param-
41 eter input to a simulation can be assigned a distribution of values, and multiple simulations can be run
42 using randomly selected values for each parameter to obtain a distribution of outcomes associated with
43 various probabilities. That approach was used to some extent for the cumulative groundwater impacts
44 analysis described in Section 5.14 and Appendix L.

3.5.4 Human and Ecological Risk Associated with Exposure to Radioactive and Hazardous Materials

Human and ecological risk estimates are subject to many of the same uncertainties associated with fate and transport as described in the previous section. An added uncertainty is the inherent variability in biological and ecological systems, such as the genetic variation in populations that may predispose a particular individual to adverse health effects following exposure to a potentially hazardous material. Data on relative risks from hazardous material exposure are typically more difficult to obtain because of the ethical constraints on experimentation with human subjects. Extrapolating risk from animal studies to humans, or extrapolations of ecological impacts between different animal species, introduces additional uncertainty into the consequence estimates. Estimates of cancer risk in very long-term analyses, such as those for groundwater quality, are likely to overestimate the risks, because they do not account for the possible development of medical treatments that could prevent those consequences in the future.

As with the environmental transport calculations the approach used in the HSW EIS was to assign conservative values to most of the input parameters used in modeling risk from hazardous material exposures. For example, the estimates of potential cancer risk from exposure to radiation at very low doses, such as those from most environmental exposures, are based on data obtained at higher exposure rates and by different exposure pathways. The effect is assumed to be proportional to the dose received, although in the case of radiation, there is no experimental or epidemiological evidence that such effects occur at very low doses. The estimates of cancer incidence or fatality from very low radiation doses are therefore conservatively high, and encompass a range of possible risks that includes zero risk.

3.5.5 Technical Maturity of Alternative Treatment Processes

Treatment technologies for most types of MLLW are specified by regulation. Where more than one technology might apply to a particular waste stream, a reference treatment technology was assumed for purposes of analysis. The consequences of waste treatment were typically estimated using conservative but realistic assumptions appropriate for the reference technology. For example, thermal treatment processes would be expected to result in greater emissions to the atmosphere than non-thermal technologies such as macroencapsulation. One uncertainty associated with MLLW treatment is the currently limited availability of thermal treatment processes for waste containing hazardous organic components. For purposes of analysis, this EIS assumed such treatment would be available at offsite commercial facilities within a reasonable time. However, an additional alternative was evaluated to consider the use of non-thermal options for those wastes in the event such treatment is not available.

With respect to ILAW, the reference treatment was assumed to be vitrification or another technology that produces a waste form having equivalent long-term performance. Other treatment technologies are currently under consideration for the low activity waste stream; however, those technologies are not sufficiently mature for detailed evaluation at this time. The uncertainties associated with long-term performance of ILAW are addressed in this EIS by considering a range of performance characteristics for this waste stream (see Appendix G).

3.5.6 Timing of Activities Evaluated in the Alternative Groups

Under all HSW EIS alternative groups, there are uncertainties related to the timing of their implementation. Timing uncertainties include:

- the technical maturity of waste treatment technologies and the amount of development necessary before design and construction of facilities could proceed
- the possibility that regulatory requirements could change, which could introduce delays by affecting the design and cost of selected alternatives
- the time required to obtain necessary permits and approvals for various treatment, storage and disposal actions
- the timely appropriation of funds by Congress to enable DOE to implement decisions resulting from this EIS
- the effect of proposals for accelerated cleanup at Hanford (DOE-RL 2002) and at other DOE facilities, which could potentially influence the timing and quantities of waste receipts.

In general, these uncertainties are addressed in this EIS by adopting conservative assumptions in analyses (that is, assumptions that would tend to maximize the estimated environmental impacts). The timing of activities evaluated in the EIS may differ from assumptions used in the analyses; however, the nature and extent of those actions are expected to be similar whenever they may occur.

3.6 Costs of Alternatives

Consolidated cost estimates were prepared for the continued operation of existing facilities, the modification of existing facilities, construction of new facilities, and operation of the new or modified facilities (FH 2003; Aromi and Freeburg 2002). The costs were calculated using a constant 2002 dollars. Some operations, such as capping the LLBGs and treatment of leachate from mixed waste trenches, would continue beyond 2046. These costs have been included as a separate category. The cost of each major facility for each alternative group is shown in Table 3.21. The increased costs for the operation of the LLBGs with the increased volume of waste can be seen. Because the additional MLLW in the Upper Bound waste volume do not need treatment, the costs for treatment facilities do not change. In the No Action Alternative Group, the increased needs for storage of MLLW and the limited volume of waste disposed of are reflected in the relative costs of the CWC and the MLLW trenches. The increased costs for the baseline operation of the T Plant Complex for the No Action Alternative Group compared with Alternative Groups A, B, and C result from the continuing need to store the K Basin sludge in the No Action Alternative. The combination of commercial MLLW treatment and modification of the T Plant Complex in Alternative Group A is less expensive than construction of a new facility, with DOE doing the majority of the treatment onsite in Alternative Group B. The consolidation of disposal facilities should lead to lower disposal costs – most easily noted in the total alternative group costs between Alternative Groups D and E and Alternative Group A.